

Homework 7

Due: Friday Oct. 24, 2014 1pm

1. Fig. PS7.1 shows a two-stage differential amplifier.
 - a) Calculate the DC operating points including the current flowing through each branch and DC voltage at each node. The DC value of the input and output nodes is set at zero. Calculate transistor small-signal parameters (i.e. g_m , r_o , C_{gs} , C_{gd}).
 - b) Draw the differential-mode and common-mode half-circuits for the amplifier and provide expressions and calculate the numerical values for the output resistance, R_{out} ; gain, v_{out}/v_{in} ; and high-frequency cut-off f_H .

MOS parameters:

$$|V_{th}| = 0.5\text{V}, k' = 200\mu\text{A}/\text{V}^2, \lambda = 0.02\text{V}^{-1}, V_{DD} = -V_{SS} = 2.5\text{V},$$

$$C_{ox} = 110.5\text{fF}/\mu\text{m}^2, C_{ol} = 0.1\text{pF}, C_{db} = C_{sb} = 0.1\text{pF},$$

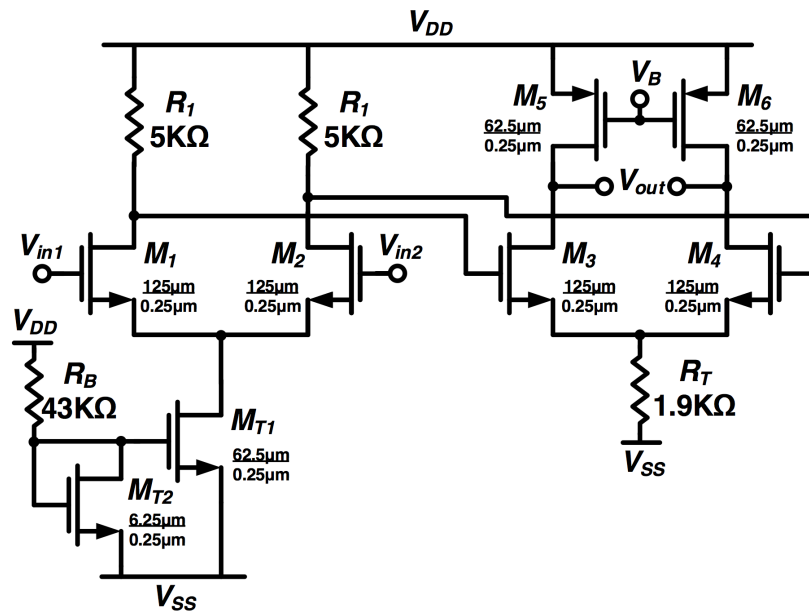


Fig. PS7.1

2. For the amplifiers shown in Fig. PS7.2, provide expressions for the gain, output resistance and high-frequency cut-off f_H , in terms of transistors small-signal parameters (i.e. g_m , r_o , C_π , C_μ , C_{cs}) for common-mode and differential-mode input.

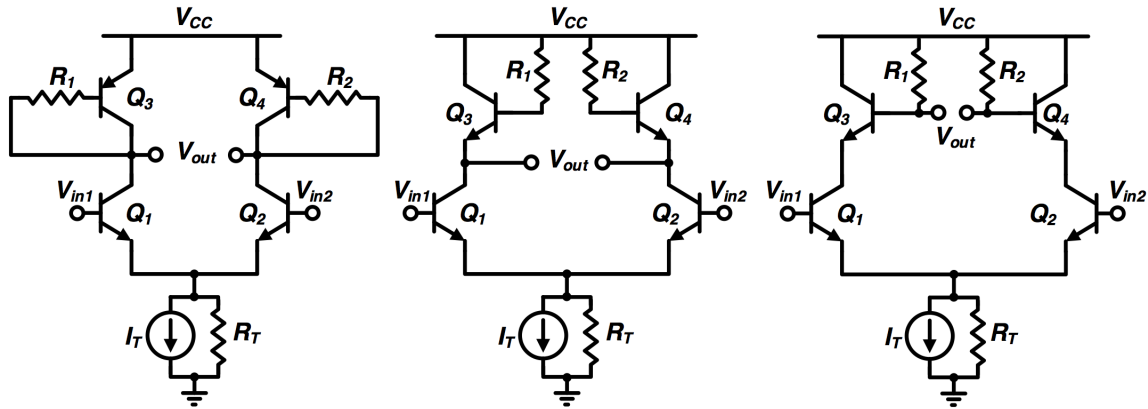


Fig. PS7.2

3. The circuit shown in Fig. PS7.3 is a two stage op amp employing cascoding. Assume $I_{SS} = 1\text{mA}$, $I_{D9}-I_{D12}$ are all equal to 0.5mA , $(W/L)_{9-12}$ are all $100/0.5$, and the two halves of the circuit are symmetric.

- Calculate the common mode voltage range at nodes X and Y over which all transistors remain in saturation.
- If at least 400mV is required across the I_{SS} current source, what are the minimum sizes, (W/L) , of M_1-M_8 in order to achieve a peak-to-peak swing of 200mV at X and Y? What are V_{b1} , V_{b2} , and V_{b3} ?
- Calculate the overall voltage gain $(V_{out2}-V_{out1})/V_{in}$

$\mu_n = 350\text{cm}^2/\text{Vs}$, $\mu_p = 100\text{cm}^2/\text{Vs}$, $t_{ox} = 9\text{nm}$, $\lambda_n = 0.1\text{V}^{-1}$, $\lambda_p = 0.2\text{V}^{-1}$, $\gamma = 0$, $V_{thp} = -0.8\text{V}$, $V_{thn} = 0.7\text{V}$.

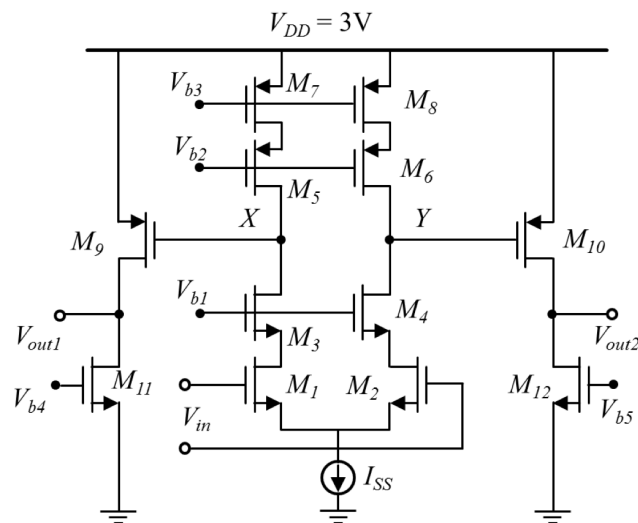


Fig. PS7.3

4. Derive the transfer function and sketch the Bode plot of the circuits shown in Fig. PS7.4. The op amp here is ideal. Specify the values of R_1 , R_2 , C_1 and C_2 to provide a gain of 60dB in the “midband frequency range”, a low-frequency 3dB point at 100Hz, a high-frequency 3dB point at 10 kHz, and an input resistance (at midband frequency) of $1\text{k}\Omega$.

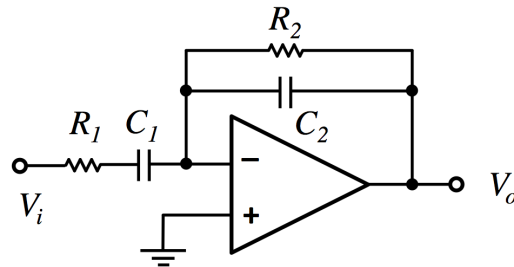


Fig. PS7.4